# 4½ Digit Panel Meter Demonstrator/ Instrumentation Boards



Intersil's 8052A/7103A precision A/D converter pair with its multiplexed BCD outputs and digit drivers combines dual-slope conversion reliability with ±1 count in 20,000 accuracy. The two chip system features performance characteristics such as 5pA input leakage, 0.002% linearity, auto-zero to 10μV with drift less than 1μV/°C, and scale factor temperature coefficients of 3ppm/°C (with external reference). With these outstanding features, the 8052A/7103A two chip system is ideally suited for LED display Digital Panel Meter (DPM) and Digital Multimeter (DMM) applications.

## DEMONSTRATOR BOARD

Two versions of the complete circuit for a 4½ digit DPM with ±2.0000 volt full scale and LED readout will be discussed. The first version, the Demonstrator Board, is shown in schematic form in Figure 1. This circuit uses the internal reference of the 8052A for conversion reference and a buffered 2-inverter CMOS RC oscillator for the clock source. The Demonstrator Board contains all the components and displays for a 4½ DPM on one, double-sided PC board. In addition, the BCD outputs, digit drivers, overrange, underrange, run/hold and busy lines from the 7103 are brought out to the edge connector making it possible to interface the DPM to a microprocessor or UART. The PC board layout diagram and component placement diagrams are shown in figures 2, 3 and 4.

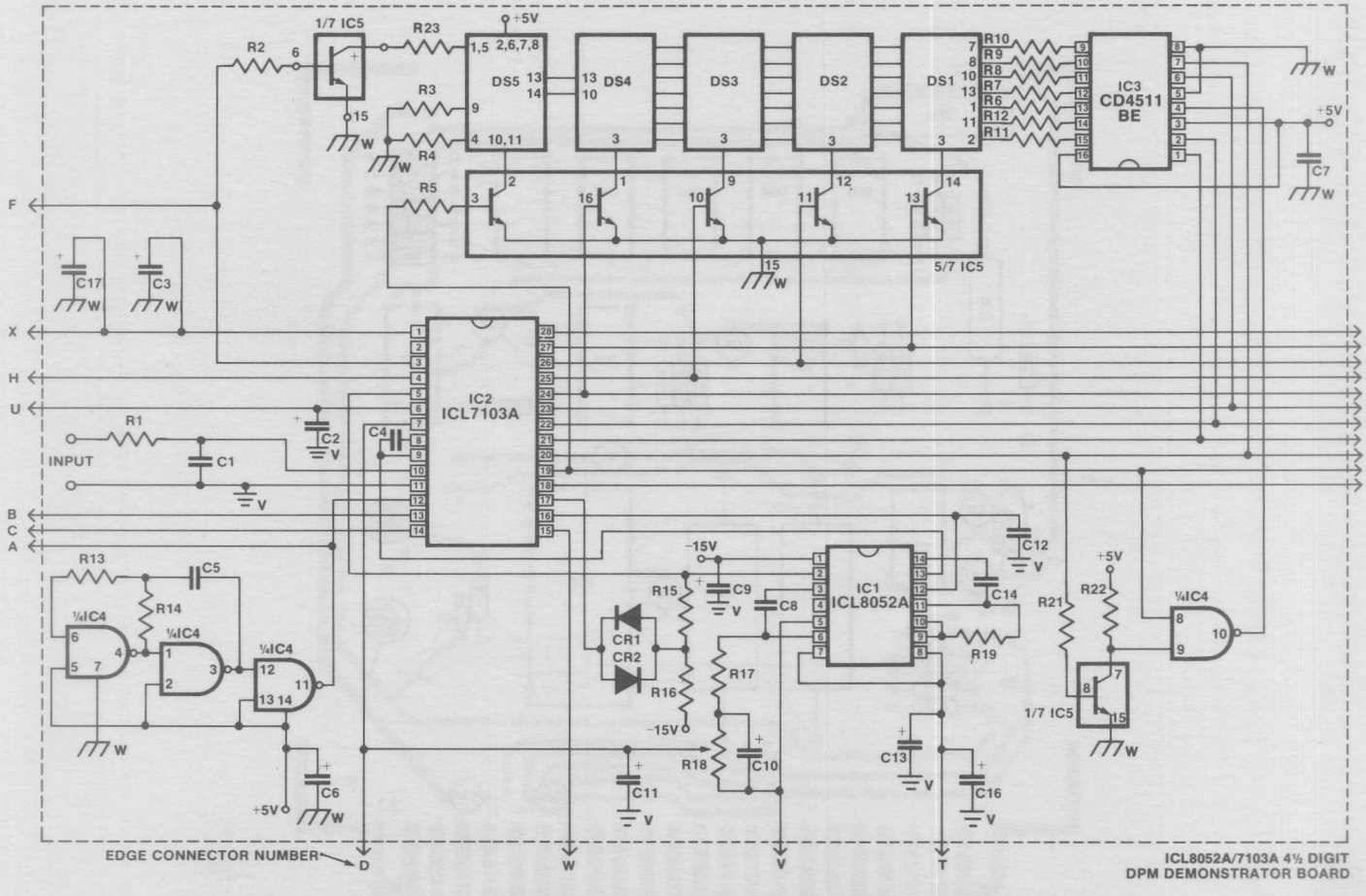
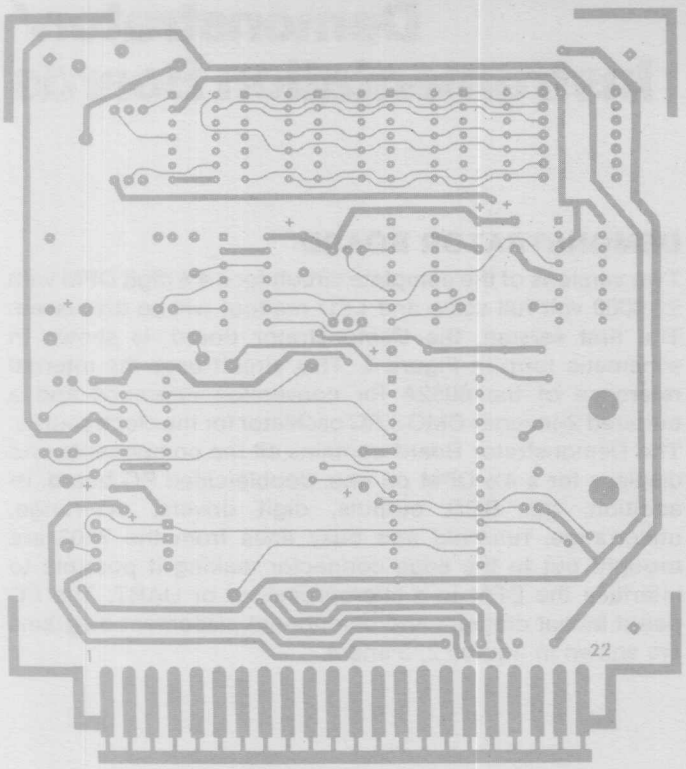
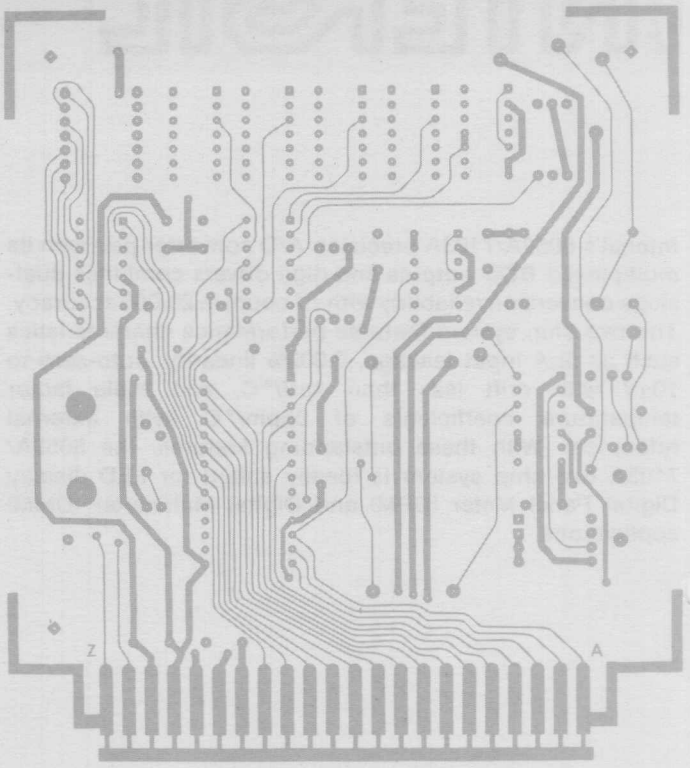



**Figure 1:** Demonstrator Board Schematic




FRONT

**Figure 2:** Demonstrator Board Component Side




BACK

**Figure 3:** Demonstrator Board Back

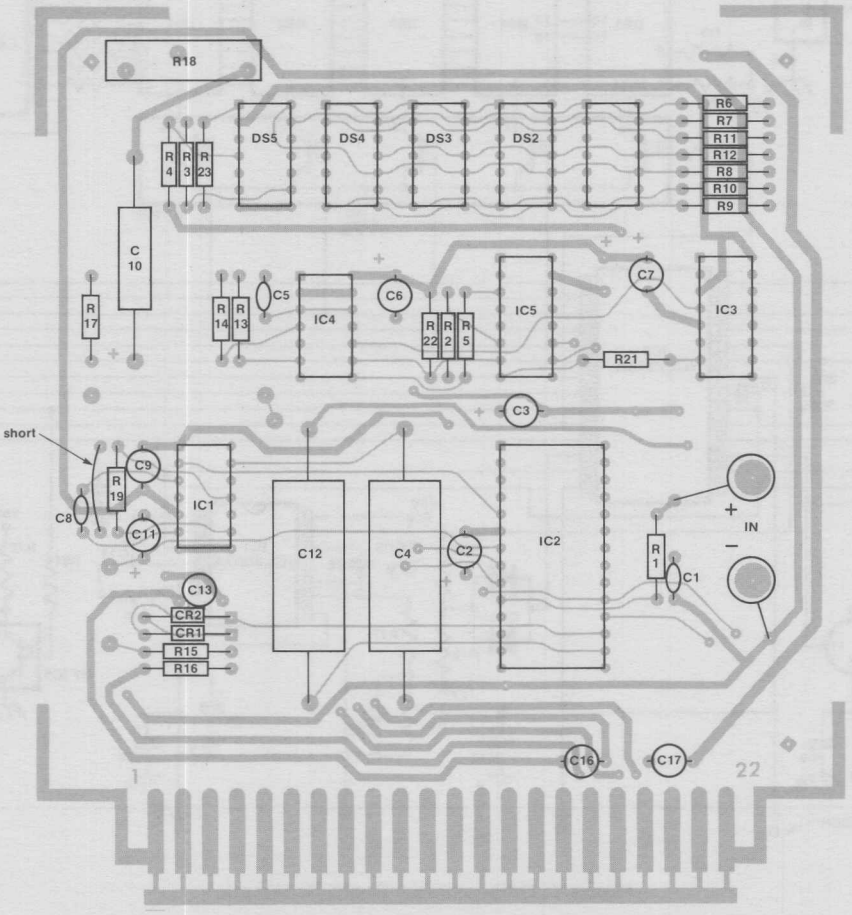



**Figure 4:** Demonstrator Board Component Placement

## INSTRUMENTATION BOARDS

The schematic diagram in Figure 5 is for the 4½ Digit Instrumentation Boards which feature a lower component count, a separate front panel display board and a compact main board. The display board uses 5 similar LED Displays for the full digits and the polarity/½ digit, with the 7-segment decoder/driver on the reverse side of the board. The main board uses the 8052 reference, a CMOS clock circuit with variable frequency adjustment and has the BCD lines, digit driver lines, supply and ground lines, and input lines brought out to the edge connector. Both boards use single-sided construction to simplify assembly and reduce fabrication costs. Figure 6 shows the main board PC layout with the component placement diagram in Figure 7. The display board artwork is shown in Figure 8 with component placement shown in Figures 9 and 10. Note that the displays are mounted on the trace side of the display board while the digit driver transistors, current-limiting resistors and the decoder/driver IC are mounted on the opposite side of the board.

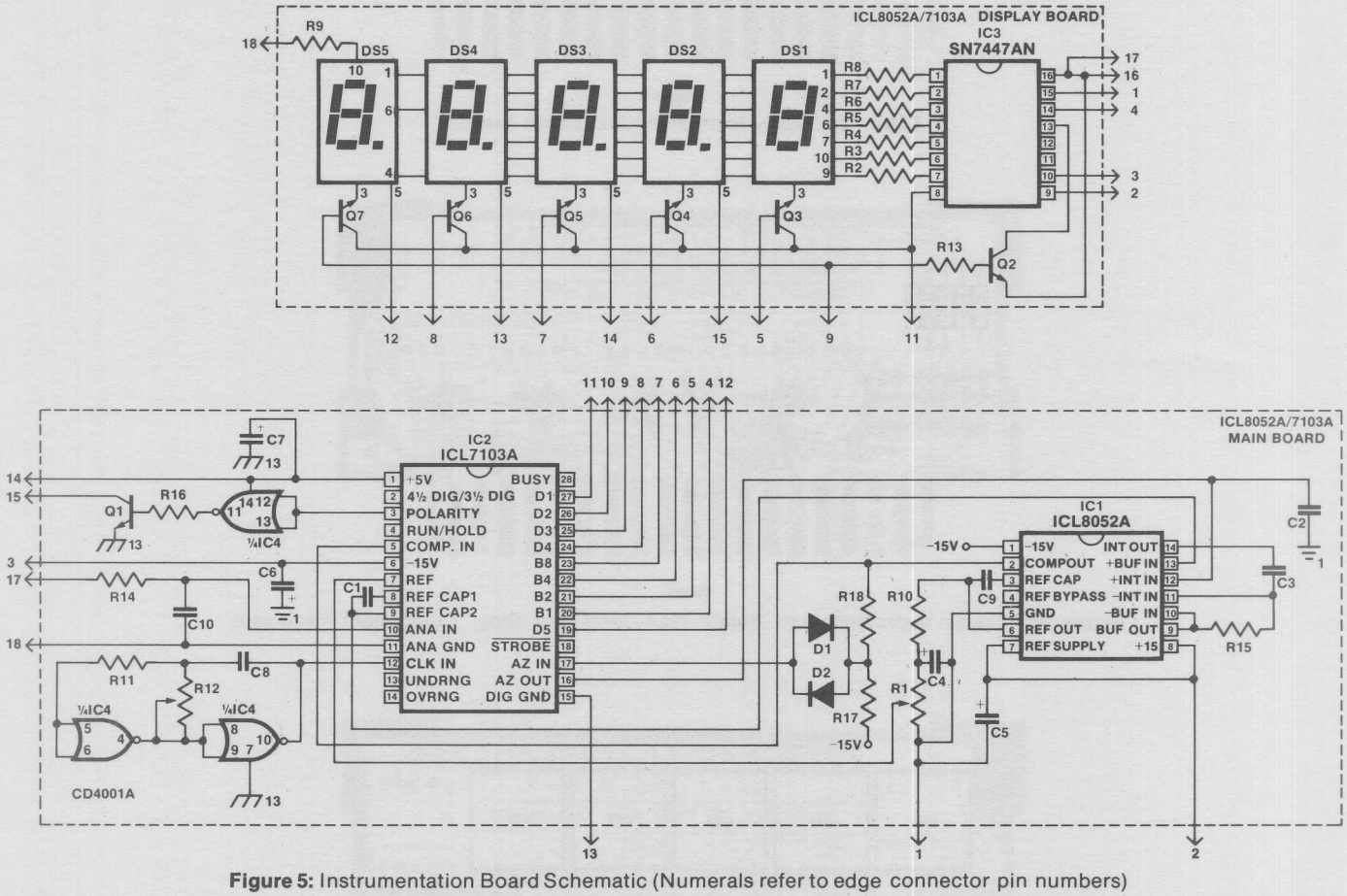



**Figure 5:** Instrumentation Board Schematic (Numerals refer to edge connector pin numbers)

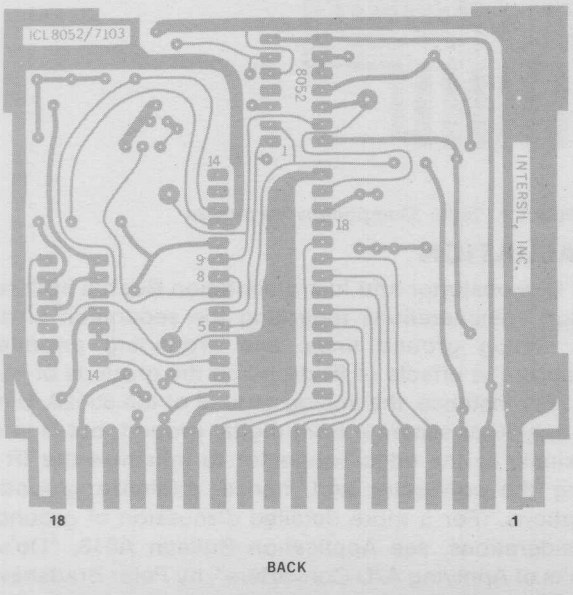



**Figure 6:** Main Instrumentation Board Back

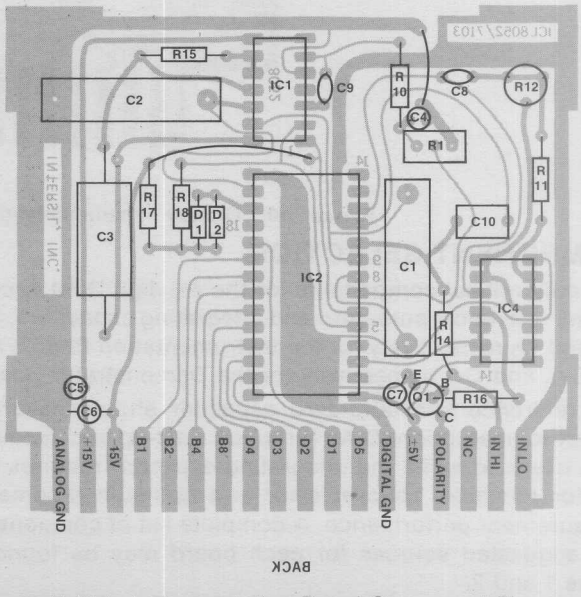



**Figure 7:** Main Instrumentation Board Component Placement

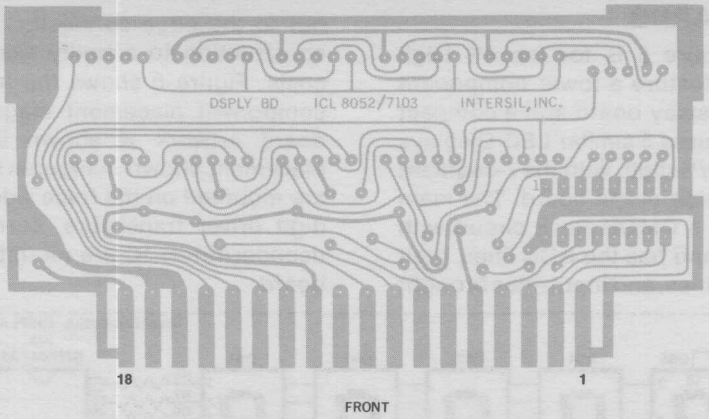



**Figure 8:** Display Instrumentation Board Artwork

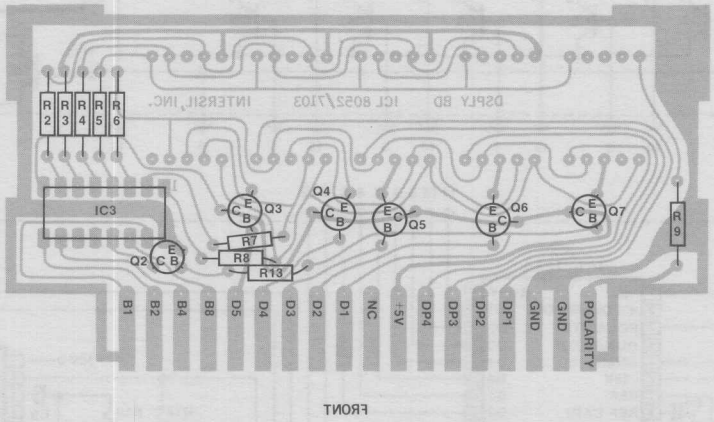



**Figure 9:** Display Instrumentation Board (Non-Conductor Side) Component Placement

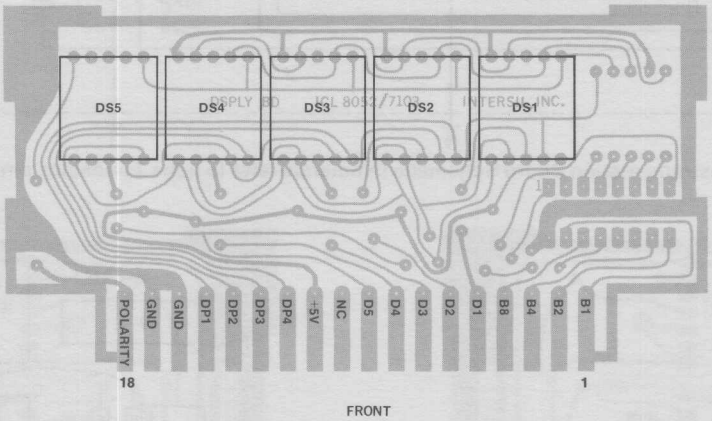



**Figure 10:** Display Instrumentation Board (Conductor Side) Component Placement

## COMPONENT SELECTION

The only critical components for the 4½ digit DPM circuits are the reference, auto-zero and integrating capacitors, ($C_1$, $C_2$, and $C_3$ respectively for the Instrumentation Boards and $C_4$, $C_{12}$, and $C_{14}$ respectively for the Demonstrator Board). The reference and auto-zero capacitor should have low dielectric absorption (D.A.) for quick start-up and recovery from overload while the integrating capacitor requires low DA for minimum rollover error and optimum ratiometric measurement performance. A complete list of components and suggested sources for each board may be found in tables 1 and 2.

## EVALUATION

The Demonstrator and Instrumentation Boards both reflect design considerations regarding the separation of digital and analog ground lines, and grounding priorities to minimize the effects of IR drops on the grounds of various IC's. For instance, the analog ground of the 8052A (pin 5) is not only kept separate from digital ground, but is in close proximity to the edge connector to minimize the IR drop along the conductor and, hence, minimize ground line variations. (For a more detailed discussion of ground line considerations, see Application Bulletin A018, "Do's and Don'ts of Applying A/D Converters", by Peter Bradshaw and Skip Osgood).

## Table I
### ICL8052A/7103A 4½ DIGIT DIGITAL PANEL METER
Electrical Parts List for Demonstrator Board

| Reference Designation | Description | Recommended Manufacturer & Part Number |
|---|---|---|
| IC1 | Analog A/D Converter | Intersil ICL8052A |
| IC2 | Digital A/D Converter | Intersil ICL7103A |
| IC3 | 7-Segment Decoder/Driver | RCA CD4511BE |
| IC4 | Quad CMOS Nand Gate, 2-Input | RCA CD4011AE |
| IC5 | 7-Transistor Array, Common Emitter | RCA CA3081 |
| C1 | 0.1μF Ceramic Capacitor | Sprague 7CZ5U104X0050D1 |
| C2,C3,C6,C7,C9-C11,C13,C16,C17 | 10μF Tantalum Capacitor | Kemet T39-C106-025AS |
| C4,C12 | 1.0μF Polypropylene Capacitor 20%, 200V dc | TRW X363UW |
| C5 | 100pF Mica Capacitor | Arco CM4FD101J03 |
| C8 | 300pF Mica Capacitor | Arco CM4FD301J03 |
| C14 | 0.22μF Polypropylene Capacitor | IMB GA2A224 |
| R1,R19,R22 | 100KΩ ¼W Resistor | |
| R2,R14,R15,R21 | 39KΩ ¼W Resistor | |
| R3,R4 | 330Ω ¼W Resistor | |
| R5 | 2.2KΩ ¼W Resistor | |
| R6-R12,R23 | 120Ω ¼W Resistor | |
| R13 | 82KΩ ¼W Resistor | |
| R16 | 300KΩ ¼W Resistor | |
| R17 | 510Ω ¼W Resistor | |
| R18 | 1KΩ Trimmer | Beckman 76PR1K |
| CR1,CR2 | Small Signal Diode | 1N914 |
| DS1-DS4 | 7-Segment LED Display | HP 5082-7653 |
| DS5 | ±1 Polarity Display | HP 5082-7656 |

## Table II
### ICL8052A/7103A 4½ DIGIT DIGITAL PANEL METER
Electrical Parts List for Instrumentation Board

| Reference Designation | Description | Recommended Manufacturer & Part Number |
|---|---|---|
| IC1 | Analog A/D Converter | Intersil ICL8052A |
| IC2 | Digital A/D Converter | Intersil ICL7103A |
| IC3 | 7 Segment Decoder/Driver | Texas Instruments SN7447AN |
| IC4 | Quad CMOS Nor Gate, 2 input | RCA CD4001AD |
| C1, C2 | 1.0 μF Polypropylene Capacitor | Plessey 171L105K160 |
| C3 | 0.22 μF Polypropylene Capacitor | IMB GA2A224 |
| C4 thru C7 | 10 μF Tantalum Capacitor | Kemet T39-C106-025AS |
| C8 | 100pF Mica Capacitor | Arco CM4FD101J03 |
| C9 | 300pF Mica Capacitor | Arco CM4FD301J03 |
| C10 | 0.1 μF Polyester Capacitor | Siemens B325600.1/10/100 |
| R1 | 1kΩ Cermet Trimpot | Bourns 3299P |
| R2 thru R9 | 120Ω ¼W Resistor | |
| R10 | 510Ω ¼W Resistor | |
| R11 | 200kΩ ¼W Resistor | |
| R12 | 100kΩ Trimmer | Spectrol 62-3 |
| R13 | 47kΩ ¼W Resistor | |
| R14, R15 | 100KΩ ¼W Resistor | |
| R16 | 4.7KΩ ¼W Resistor | |
| R17 | 300kΩ ¼W Resistor | |
| R18 | 36kΩ ¼W Resistor | |
| D1, D2 | Small Signal Diodes | IN914 |
| Q1 thru Q7 | NPN Transistor | Motorola MPS 3704 |
| DS1 thru DS5 | 7 Segment LED Display | Fairchild FND507 |

One problem that exists on both PC boards regarding supply line variations is that of the CMOS clock source. Since the supply for the RC oscillator is shared with the LED display, any variation in supply voltage due to the display reading will also vary the supply voltage to the oscillator. The point at which this variation becomes critical is when the display changes from a full scale reading to overrange; i.e., 19999 to 0000. When in overrange, the display alternates between a blank display (all segments off) and the 0000 overrange indication. The supply voltage to the CMOS oscillator varies enough to cause a shift in the clock frequency. This shift occurs during the signal integrate/reference integrate phase of conversion causing a low display reading just after overrange recovery. For instance, if the signal voltage is 1.99995 volts, the display reading should toggle between 1.9999 and overrange. However, the clock frequency shift causes the display to read 1.9992 just after the 0000 overrange display before returning to the 1.9999 reading. The severity of the reading variation after overrange recovery depends on the magnitude of the clock variation which gets back to the stability of the supply voltage line to the RC oscillator.

The clock supply voltage modulation has been minimized on both boards by separating the display supply lines from the clock supply line. To eliminate any clock frequency shift completely, a clock source using Intersil's LM311 voltage comparator in positive feedback mode (Figure 11) could be substituted.

Another problem encountered with the 8052A/7103A DPM is that of gross over-voltage applied to the input. Any voltage in excess of ±2.0000 volts may cause the display to give an erroneous voltage indication. The reason this occurs is the integrator continues to ramp towards the supply (positive for negative input voltages, negative for positive inputs) until the integrator output saturates. When this occurs, the integrator can no longer source (or sink) current required to hold the summing junction (Pin 11) at the voltage stored on the auto zero capacitor. As a result, the voltage across the integrator capacitor decreases sufficiently to give a false voltage reading.

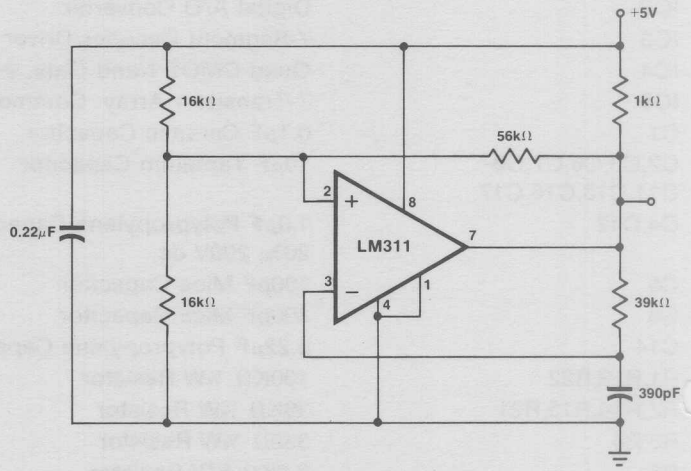



**Figure 11:** LM311 Clock Source

A simple solution to this problem is to use junction FET transistors across the integrator capacitor to source (or sink) current into the summing junction and prevent the integrator amplifier from saturating. Using an N channel and a P channel JFET, connect drains to pin 11 of the 8052A, sources to pin 14, the gate of the P channel to +15V, and the gate of the N channel to −15V (Figure 12). With the JFET's in this configuration, input voltages ranging from 2 to 6 volts positive and 2 to 10 volts negative will cause the correct overrange indication to occur.

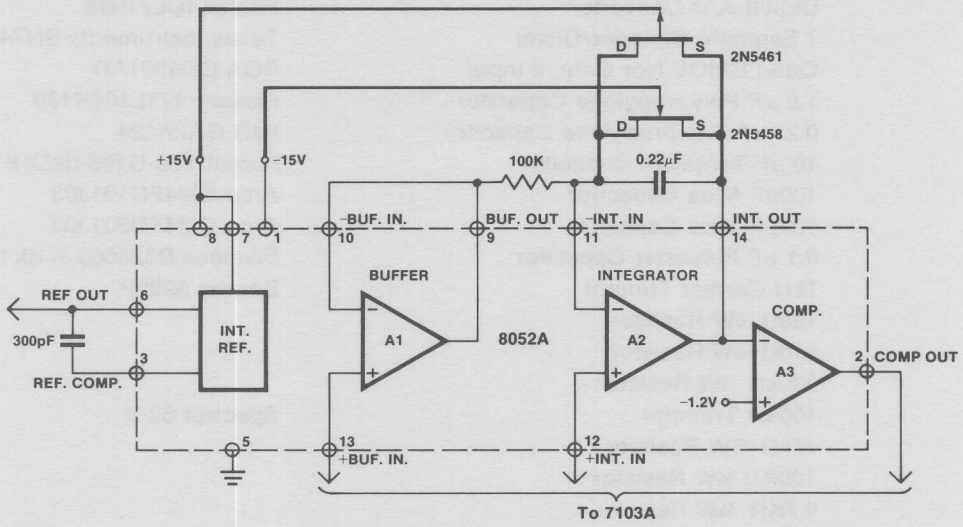
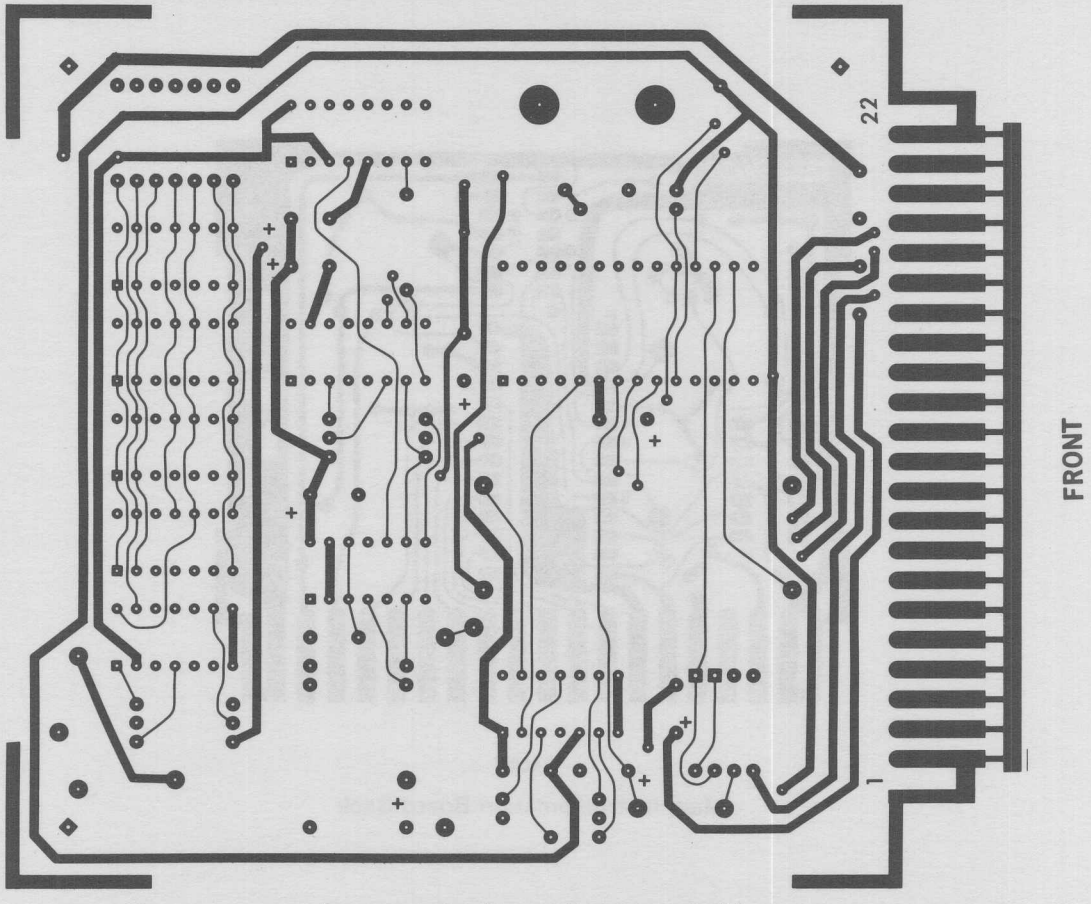
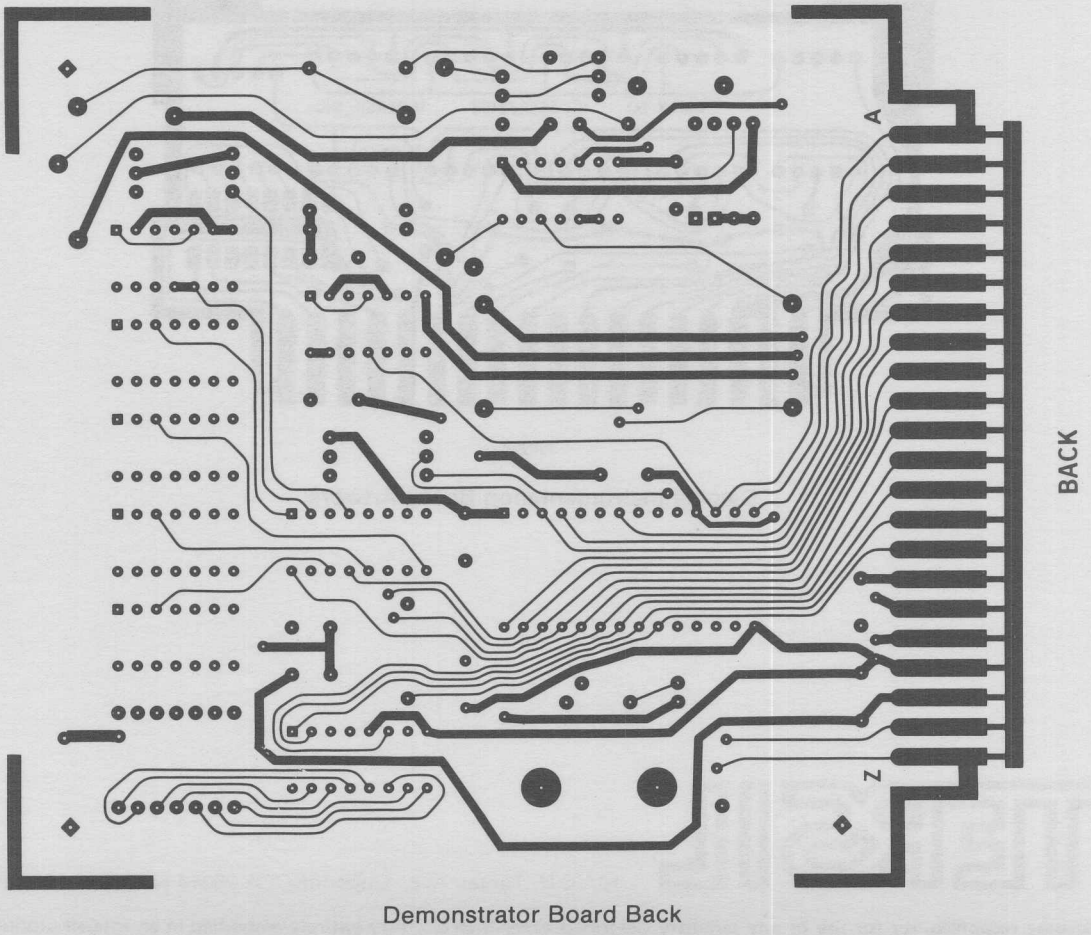



**Figure 12:** Gross Overvoltage Protection Circuit

**APPENDIX** - Board artwork for Printed Circuit Generation (Scale 1:1)

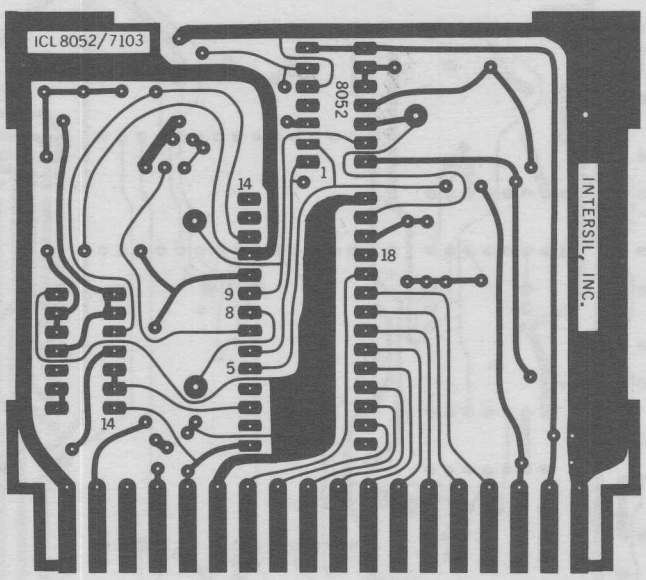



Demonstrator Board Component Side



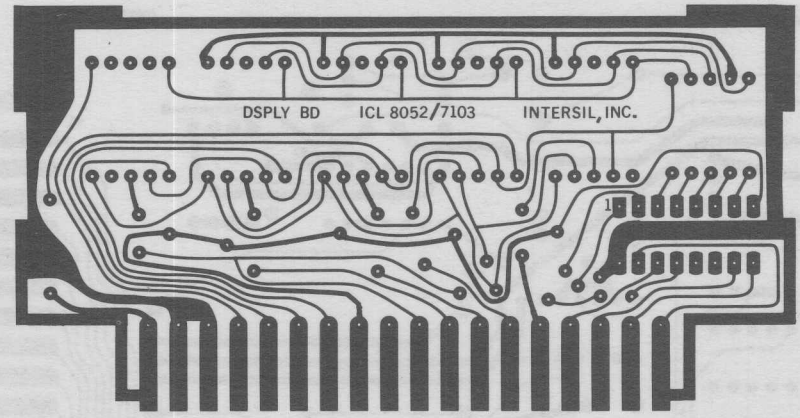

Demonstrator Board Back

**APPENDIX (Contd.)** - Board artwork for Printed Circuit Generation (Scale 1:1)




BACK

Main Instrumentation Board Back




FRONT

Display Instrumentation Board Artwork

INTERSIL

10710 N. Tantau Ave., Cupertino, CA 95014 (408) 996-5000 TWX: 910-338-0171